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PREDICTING HUNTER SUCCESS BY MEANS OF A SPRING CALL COUNT OF GAMBEL QUAIL[1]

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Abstract: A study of spring call counts of male Gambel quail (*Lophortyx gambelii*) in relation to hunting success has revealed a linear relationship which has made possible the accurate prediction of hunter success for the year of the count. On three study areas in central Arizona call counts in April and May were correlated with hunter success during the first 2 weekends of the quail season. A linear regression equation was used as a predictor for each area. Further analysis showed a significant difference in mean hunting success on the three areas after adjusting to a similar call index. These differences were largely accounted for by cover and topography which influenced success. A knowledge of the relationship between site factors and success of hunters made possible the use of a single predicting equation for all three areas. The average absolute deviation of predicted success from actual success was only 12 percent.

During the past 25 years, census methods for a variety of game birds have been developed by exploiting the fact that the males of many avian species give a characteristic call during the breeding season. Crowing pheasants (*Phasianus colchicus*), drumming ruffed grouse (*Bonasa umbellus*), booming prairie chickens (*Tympanuchus cupido*), and whistling bobwhite quail (*Colinus virginianus*) are among the forms which have been censused in this manner (Hickey 1955:329). Such counts are generally thought to reflect the spring population level of monogamous species when the sex ratio is constant from year to year. In the case of polygamous species, as the pheasant, a further knowledge of the spring sex ratio is essential to an accurate evaluation of population levels.

Since spring call counts generally are only an indication of the number of breeding birds, they would not appear to be indicative of the eventual fall population level because of annual variation in hatching success and survival of young. Only if hatching success and survival of young were constant would call counts be indicative of the size of the fall population. Several investigators have tested the relationship of call counts to the population level of bobwhite quail.

Bennitt (1951) reported a positive correlation between spring counts of whistling bobwhite quail and success of hunters in the fall. From this he developed a linear equation describing the regression of hunting success on the call-count index. Hunting success was predicted for each of eight regions in Missouri using this common regression formula and was then adjusted by means of a regional correction index. This procedure presumably corrected for heterogeneity in means of regions which remained even after they were adjusted to a common call-count index.

Rosene (1957) compared summer counts (1950–53) of whistling bobwhite quail with fall and winter covey counts. This work was done on 10 areas in Alabama and South Carolina. There were 3 years of data on 6 study areas and 4 years of data on 4 study areas. The results of all years and locations were pooled to estimate the regression coefficients and to formulate a common predicting equation for all areas and years. Rosene concluded that changes in the call count would reliably show changes in number of fall coveys on areas of a specified size.

[1] This study was conducted under Arizona Federal Aid Project W-78-R.

Norton et al. (1961), in a discussion and critical analysis of their papers, largely invalidated the findings of both Bennitt and Rosene. Bennitt (1951:24) found that his average departure of predicted hunting success from actual (average of eight regions for 10 years) was 7.2 percent. The average departure of the yearly statewide average success from the 10-year average was only 10 percent. In other words, the the accuracy in predicting statewide hunt success was improved by only 3 percent by using the call-count index as opposed to using merely the 10-year average as an estimate of success.

In examining Rosene's data, Norton et al. (1961) found that a regression appropriate to estimating coveys on an additional area in a given year was used to make predictions in time. Actually, there was no significant regression of coveys on the yearly mean call count for areas within states.

From the evidence presented in these papers, it appears that counts of whistling bobwhite quail are inadequate for predicting either hunting success or quail population levels where populations fluctuate as little as they do in the midwest and southeast. In Arizona, however, sharp yearly differences in rainfall coincide with rather dramatic changes in population levels of Gambel quail (Swank and Gallizioli 1954). For this and other reasons to be discussed, call counts have been found to offer a way for predicting hunter success with a high degree of accuracy.

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METHODS

This study was conducted on three areas, each sampled by a 20-mile route along an arbitrarily selected road. Counts of calling male quail have been made at Oracle (23 miles northeast of Tucson) and at Pinnacle Peak (25 miles northeast of Phoenix) since 1958. A third area, about 8 miles east of the town of Cave Creek, was added in 1960.

The Cave Creek route is only about 25 miles from the Pinnacle Peak route. These routes are in a desert shrub type dominated by saguaro (*Carnegiea gigantea*) and palo verdes (*Cercidium* sp.) with a bur-sage (*Franseria dumosa*) understory. Grasses, except for ephemeral annuals, are scarce. Elevation along these two routes varies from 1,500 to 2,000 feet. The Oracle Junction area is about 100 airline miles south of the other two, at an elevation varying from 3,000 to 4,000 feet. Desert shrub and mesquite grassland types are interspersed along the route. Mesquite (*Prosopis juliflora*), jumping cholla (*Opuntia fulgida*), and palo verde are dominant at lower elevations, and catclaw (*Acacia greggii*), mimosa (*Mimosa* sp.), and two species of cholla cactus (*Opuntia* spp.) at higher elevations. Understory consists of a variety of perennial grasses and burroweed (*Aplopappus* sp.). While the three routes are not representative of habitat types of Gambel quail in Arizona, they are typical of quail areas near the population centers of Tucson and Phoenix which support the bulk of the state's quail hunting.

Counts during the period 1958–62 were made at 2-week intervals from mid-March through June. Having thus defined the time limits within which the peak of calling was likely to occur, the counts in 1963 and 1964 were made at 1-week intervals from about April 15 to May 20.

Because preliminary work by Gallizioli (1956) indicated there was little or no calling until approximately sunrise, counts began 15 minutes before official sunrise. Traveling the route by automobile, the sin-

Table 1. Summary of quail call count* and hunt data from three study areas in central Arizona, 1958–64.

Area	Category	1958	1959	1960	1961	1962	1963	1964
Oracle Junction	Call count	61	24	103	25	75	62	41
	Quail per trip	3.81	2.70	6.40	2.57	6.09	4.84	2.91
	Percent young in kill	75	34	80	10	72	62	40
	October–March precipitation	13.4	4.2	10.7	4.1	9.5	10.3	4.2
Pinnacle Peak	Call count	83	10	94	22	59	25	15
	Quail per trip	3.53	1.37	3.74	1.20	2.83	1.70	1.60
	Percent young in kill	63	17	70	25	73	53	45
	October–March precipitation	7.8	4.0	12.7	2.0	9.4	4.8	5.2
Cave Creek	Call count	–	–	72	8	64	36	26
	Quail per trip	–	–	2.96	0.64	2.55	1.82	1.38
	Percent young in kill	–	–	71	13	80	51	27
	October–March precipitation	–	–	12.7	2.0	9.4	4.8	5.2

* The call-count index for a route is the mean of the highest count and the counts preceding and following the high count.

gle observer stopped at 1-mile intervals, listened for 3 minutes, and recorded the number of single-note calls characteristic of unpaired cocks (Gorsuch 1934). Each 20-mile route required about 2 hours to complete. The call-count index used for a route was the mean of the highest count and the counts preceding and following the high count. This was a somewhat arbitrary index. But, since there was no replication of the call counts, this provided a means of softening the effect of unusually high or low counts.

At each study area, information on success of hunters has been obtained at a check station during the first 2 weekends of the quail season, which has opened on or about October 1 since 1958. Success was based on the number of quail bagged per man-day, where a man-day is one hunter in the field for one day, regardless of time spent hunting. The success index is the total number of quail taken during the first 2 weekends divided by the number of hunters.

Just prior to the hunting season in 1964, a classification of vegetative cover was made on each route. This cover index was obtained by use of a cover density board (de Vos and Mosby 1960:6). At 1-mile intervals, measured by automobile odometer, one man walked a distance of 20 yards at a right angle to the road and placed the board so as to be visible to an observer in the driver's seat of the survey vehicle, who read the amount of board covered. The cover index for the stop was an accumulation of the numbers on the board which were visible subtracted from the maximum reading of 36. The board was numbered from top to bottom from one to eight. The board was 4 feet in length and each cover increment was 6 inches on the board. By this method of reading, the greatest weight was given to low ground cover. The cover index for the route was the average of the 20 cover readings.

A subjective classification of topography also was made of each area. This was based on a scale from zero to three, representing relative steepness of terrain.

RESULTS

The pertinent data from check stations and call counts are summarized in Table 1.

The relationship between call-count data and quail per man-day presented in the above table is shown graphically in Fig. 1. The functional form of this relationship is assumed to be

$$Y = \alpha + \beta\,(X - \bar{X})$$

where Y = *quail per hunter trip*
X = the observed call count
$\bar{X}$ = mean call count, all years

The estimating equations for the three areas are

Oracle Junction: $Y = 1.200 + 0.0535X$ (1)
Pinnacle Peak: $Y = 0.944 + 0.0304X$ (2)
Cave Creek: $Y = 0.448 + 0.0345X$ (3).

There was a high linear correlation between call counts and quail per hunter trip on each area. The coefficients of correlation were 0.94 at Oracle, 0.98 at Pinnacle Peak, and 0.99 at Cave Creek. All were significantly different from zero at the 99 percent level of confidence. This suggests that hunter success on each of these areas might be predicted with a high degree of reliability. It suggests that, were we willing to collect a similar amount of data on hunting success and call counts on other areas, an equation appropriate to predicting hunter success on each new area could be found and a similar level of reliability achieved. This, of course, assumes that the relationships found on these three study areas are representative of what would be

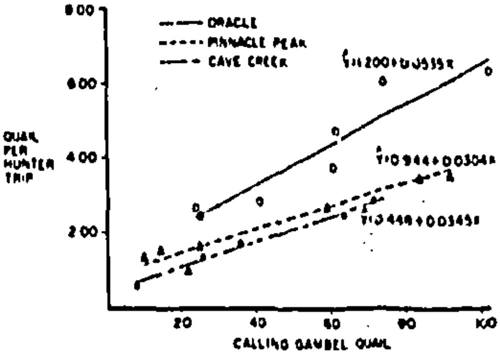

Fig. 1. Relationship between calling cock Gambel quail and hunter success.

found on other areas, at least with respect to the linearity of regression.

Obviously, the cost in time and manpower would prohibit a similar effort in each area on which we wished to make a prediction of probable success of hunters. What is needed is a single equation which can be applied anywhere in the state where a call count can be made. The approach which we used was to find auxiliary variates which would explain the remaining variation in hunting success on the three study areas which was not accounted for by the estimated linear regression of hunt success on call counts alone. These variates, of course, had to be biologically meaningful.

The analysis of covariance technique was used to evaluate further the parameters found in equations (1), (2), and (3) and to determine the validity of using a predicting equation common to all three areas. The covariance analysis is presented in Table 2.

There is a significant amount of variation in the parameter β between areas (line 3 of Table 2). This would suggest using different area parameters or using a common b at the expense of reliability in predictions. Furthermore, line 2 of Table 2

Table 2. Covariance analysis of call index and quail per hunter trip.

Source of Variation	Sum of Squares	DF	Mean Square	F Value
1. Between $\hat{b}$ and $\bar{b}$*	10.6545	1	10.6515	70.74
2. Deviation of area means about their regression	0.0035	1	0.0035	0.024
3. Between individual area slopes	1.6013	2	0.0006	5.32
4. About individual area regressions	1.9581	13	0.1506	
5. About the overall regression line	14.2174	17		
6. Due to overall regression line	31.1171	1		
7. Total	45.3345	18		

* $\hat{b}$ is estimated regression coefficient common to individual lines (temporal); $\bar{b}$ is estimated regression coefficient for area means (spatial).

reveals linear relation between the area means (quail per trip). The slope of this regression is significantly different from the slope of a least-squares regression common to the three areas (line 1, Table 2). This is sufficient proof of significant variation between area means in quail per trip even after adjusting them to a common call-count index. Table 1 shows that hunt success at Oracle will always be higher than at the other two areas even when call counts are similar. There apparently are site characteristics which affect hunting success independently of the number of birds available.

The model in Fig. 2 may help to explain some of the results found and also illustrate the following proposed hypothesis: even though in any area call counts are well correlated with hunt success, other factors cause differences in success between areas independently of the number of calling birds. Such factors are virtual constants whose influence varies but little from year to year and which, consequently, do not disturb the temporal relationship between call counts and hunter success. Topography and ground cover are two such elements. There are probably other less conspicuous habitat features which also influence hunter success on any individual area.

An attempt was made to determine the relation of topography and ground cover density to hunter success on the three areas of this study and to develop a predicting equation common to all three areas.

In order to predict quail per trip in time, the regression of yearly mean hunter success on the yearly mean call-count index was computed using the mean hunter success and mean call counts for all areas combined. The predicting formula was

$$Y = 1.10196 + 0.03744X_1 \quad (4)$$

where X_1 = quail call-count index (average for three study areas).

The procedure of computing a call-count regression coefficient common to the three areas is not without risk because of the significant difference in the predicting parameters for the three areas (line 3, Table 2).

Next, an arbitrary topographical classification was made of each area, based on the hypothesis that an increase in slope adversely affects hunting success. In addition, on the assumption that the amount of low ground cover favorably influences hunting success, a cover index was computed according to the procedure outlined.

X_2 = topography where $0 \leq X_2 \leq 3$
X_3 = ground cover where $0 \leq X_3 \leq 36$.

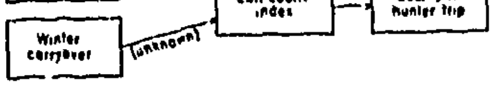

Fig. 2. Model of suggested relationship between call counts of Gambel quail and hunt successes.

These are factors which presumably cause hunting success on one area to differ from another even though the call counts are the same. Each area mean hunting success was first adjusted to a common call index (mean count, all areas and years) of 47.6 using the individual area regressions (1), (2), (3). Then the regression of adjusted area means on topography and ground cover yielded the following equation:

$$Y = -0.691 - 0.347X_2 + 0.235X_3 \quad (5).$$

Combining the spatial and temporal regression coefficients yielded the following prediction equation:

$$Y = -2.465 + 0.0374X_1 - 0.347X_2 + 0.235X_3 \quad (6).$$

This predicting equation was tested by comparing predicted hunter success for each area in each year with the actual success. The average absolute deviation from actual hunting success was 12.24 percent. The data for locational factors is based on only three areas and does not permit an accurate estimate of their effect. The hunting success predictor will be further tested on several additional areas in widely separated regions of Arizona where we anticipate obtaining hunter-success and call-count data.

Many assumptions underlying the effective application of such a predicting equation cannot be wholly justified. The areas of the study were not randomly chosen, and, therefore, the parameters found cannot be considered to be representative of a region or even of the state as a whole. Also, the correlations, which were arrived at by including spatial factors, could be coincidental rather than causative. Nevertheless, the results on these three areas are encouraging and would appear to justify any risk in adopting the technique. The least that can be said is that the call count is a far better indicator of fall populations and eventual hunter success in Arizona than any technique yet designed.

DISCUSSION

In developing the prediction equation for hunter success it was not necessary to explain in terms of cause and effect the relationships among the variables involved. It was sufficient to consider variation found in the predicted variable (hunting success). However, in the conduct of this study many facts have come to light which contribute to an understanding of causal factors.

If the call count was mainly an index to the spring population level, it would certainly not be as good a predictor of hunt success as it has been in Arizona. An index only of the size of the spring adult population with no foreknowledge of hatch or survival of young would be a poor basis for a fall hunt success prediction. Breeding success in Arizona varies markedly from year to year. This is evidenced by the percent of juveniles in the fall bag, which has varied from 13 percent in one year to 80 percent the following year in the same area (Table 1). Since there is nonetheless a good correlation between success of hunters and call count it is clear that the call count must be more than an index to the population level of adults in the spring. It must be chiefly an index to reproductive success, indicated by a highly significant correlation ($r = 0.91$) between call count and percent of juveniles in the fall bag. In addition, the percent of juveniles in the fall bag explains about 94 percent of the variation in hunting success, the call count about 97 percent. These values were obtained from the yearly averages of the three areas' data. Thus, it appears that reproductive success will largely determine what the hunting success will be, but the call count indexes it even more closely be-

Table 3. Comparison of spring predictions of fall hunt success and actual kill per man-day.

Study Area	Year	Quail Bagged per Man-Day: Predicted*	Quail Bagged per Man-Day: Actual†	Percent Difference
Oracle Junction	1963	4.53	4.83	+6.6
	1964	3.52	2.91	−17.3
Pinnacle Peak	1963	1.65	1.70	+3.0
	1964	1.34	1.60	+19.4
Cave Creek	1963	1.63	1.82	+11.7
	1964	1.34	1.35	+0.7
Average deviation				9.8

* In early May from call-count data.
† From check station data, October.

cause it takes into account some other factor, apparently the spring population level.

In Arizona, the population level of Gambel quail in the spring is not necessarily synonymous with the number of breeding birds. Whether an adult bird is also a breeding bird depends on whether it is in breeding condition. Breeding condition, in turn, depends on winter precipitation and the resultant green feed high in vitamin A; following a dry winter, sex organs fail to develop properly and quail remain in winter coveys and may not even pair off (Hungerford 1964).

The ultimate effect of winter precipitation on breeding success is seen in the high positive linear correlation between the percent of young in the hunters' bag and the previous total of October through March precipitation. For the period 1958–64, the correlation coefficient was 0.91 at Oracle and 0.85 at Pinnacle Peak. For the period 1960–64, inclusive, the correlation coefficient at Cave Creek was 0.85 (Fig. 1).

In a year marked by abundant winter precipitation, a high percentage of the cock population will be in breeding condition and will be calling at the time the call counts are made. Although supporting data are lacking, empirical evidence supports the view that a calling cock is one in which gonadal recrudescence has progressed to the point where he becomes interested in attracting a mate. Following a dry winter, a small percentage of the cocks will be calling. Since the number of birds in breeding condition will be the prime determining factor of the number of young which will be produced, it follows that counts of calling cocks will be related to production of young, to the subsequent fall population, and, therefore, to hunter success.

In an effort to test the merits of the technique as a practical game management tool, predictions of hunter success were made in the springs of 1963 and of 1964, based on the previous years' correlation of call counts and hunt success and the current year's call-count index. Predicted average kills per man-day for the first 2 weekends of the season were agreeably close to the actual kills per man-day as subsequently determined from check station data (Table 3). The predicting equation (equation 6) gave an average deviation of 12.2 percent from the actual hunting success. However, when tested in 1963 and 1964 by predicting before the hunting season, mean deviation was only 9.8 percent from actual success.

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